Radar Systems and Radio Aids to Navigation

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RADAR SYSTEMS AND RADIO AIDS TO NAVIGATION

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FOREWORD

The ever riding consideration in conduct and management of aviation and maritime transport is to ensure safety. With the growth of aviation and particularly with introduction of fast moving jet-aircraft, this aspect is now of paramount importance. It is, however, not perceived by millions of passengers that a lot of investment, a large number of systems of equipment and dedicated efforts behind the screen are required to enable them reach their destination without any hazard. Thanks to the current progress in technology, it is now possible to monitor and control all flights from take of to landing provided there is enough money with the provider agencies.

The subject of 'Radio Navigational Aids' has gone through a process of rapid development over the past decades. Direction during and Hyperbolic radio-navigation aids were in extensive use during those early days. Primary radars were also developed to a stage where reliable service could be given for control and tracking. Development and use of VOR and DME constituted significant milestones in provision of accurate and reliable enroute navigation systems. Airborne direction finders working in conjunction with ground based Non-directional beacons became an integral part of essential airborne aids. With the advent of Instrument Landing System safe landing during adverse weather conditions has been possible.

The International Civil Aviation Organisation (ICAO) established standards in relation to various radio-navigation aids. The different types of facilities have been conveniently classified under categories of (*i*) Long distance aids (*ii*) En-route aids, (*iii*) Approach and landing aids and (*iv*) Airport-zone aids. As a result of constant interaction amongst designer, sponsering agencies, users and concerned International Organisation, system development have made rapid strides producing a variety of versatile aids such as Doppler VOR, MLS, Internal Navigation equipment, Omega and Satellite Navigation system. In the field of radar, Monopulse SSR techniques, data transmission capability and signal processing advances have resulted in highly accurate and versatile systems.

In the present textbook, the authors have covered a number of the above subject starting from the very fundamentals. A separate chapter deals extensively with antennas for Navigational aids. Next, two chapters have been devoted to direction finding principles,

homing systems and ILS. Hyperbolic Navigation Systems including Omega systems have been described in detail in another chapter. Principles of radar and radar systems have been covered very well in several chapters. Radar target characteristics have been adequately described. The topic of radar clutter will be very useful in understanding of the various responsible for this phenomenon. The various techniques of radar signal processing have been covered very well. The authors have included a chapter on various radar system intended for different, applications including remote sensing. On the whole, considering the extent of coverage and excellent treatment of various subjects, this book is expected to meet the long-felt requirements of a suitable university standard text-book for students and a wide cross-section of user communities.

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PREFACE

During the last few years after the publication of the first edition, new application areas of Radar System and Radio Aids to Navigation emerged and led to phenominal development of these systems in certain directions. Some of these areas include, Radar Cross Section (RCS) measurement systems based on instrumentation radars, dual polarisation Doppler radar at millimeter waves for measurements of cloud patterns over an airport, winds, updrafts and downdrafts in storms and dropsize distribution of rain and hailstones ; Special Atmospheric Probing Techniques. While all these were added in earlier edition, many more new developments are being added in this edition also. Chapters on Satellite Navigation, Vessel Traffic Management System and Mathematical Preliminaries have been also further revised, besides these new chapters on Atmospheric Radars (an introductory chapter), Navigation and Modern Measuring Techniques, Millimeter Wave Radars and Radiometers and Doppler Radar Development and Remote Sensing Research have been added so that the book may be useful to the R & D organisations engaged in the development and maintenance of the systems and to the user organisations like National Airport Authority (NAA) and India Meteorological Departments (IMD) and Defence Organisations for the maintenance of their operational systems in the area. Also Review Questions and Multiple Choice Questions and Answers have been added in Appendicies from the examination point of view for the students.

The fundamental objective of the radio navigational aids is to supply the navigator with data about speed of motion, height, position and other relevant navigational parameters. The techniques of finding these parameters have got utmost importance to a Radio Engineer. Moreover, the security of navigation is ensured by introducing certain special radio aids to detect for instance, an impending thunderstorm, which may affect both the aircraft and the ship, and microburst or windshear which prove to be hazardous during the landing phase of an aircraft. The book has been designed so that it can serve the purpose of professionals in the field to a greater extend. The subject matter widely covers B.E., B. Tech., AMIETE, M. Tech. and M. Sc. courses in Radar Systems and Radio Aids to Navigations. The M. Tech. course on Atmospheric Science recently introduced in Universities is also adequately covered in Chapters 10, 10A, 11 and 11A, which are discussed in Seventh Edition for Modern Techniques and Radio Navigation.

—AUTHORS

ABOUT THE AUTHORS

Professor A.K. Sen obtained M. Sc. (Tech.) in Radio Physics and Electronics, in 1957 and Ph. D. in 1968 from Calcutta University, joined the Institute of Radio Physics and Electronics (C.U.), as a faculty since 1962. He has published over 200 research papers in International and National Journals, guided 15 Ph. D. students. He is the Chief investigator and Programme coordinator of 13 ongoing R & D projects, sponsored by UGC, MHRD, AICTE, ADA, DRDO, DST, Govt. of India, Govt. of West Bengal and TISCO and supervised earlier 5 more projects sponsored by DOE, CSIR and UGC. He is the Director and Programme Coordinator of the "Eastern Centre for Research in Astrophysics" (ECRA) sponsored by UGC and that of the "Training Programme in Millimeterwave Technology and Wave Propagation" initiated by DOE and sponsored by State Govt. of West Bengal. He published several books including, this one on "Radar systems and Radio aids to Navigation". Khanna publishers (1988, 1992, 1993, 1995 & 1997). "Mahakashe Vigyan", Vigyan Tathya Kendra, "Satabarsher Aloy. Tin Vigyani", Viswakosh Parishad 1993 and the Chapter on Sun weather climate relationships" in the book on "Sun, Space and earth" published by Indian National Science Academy (INSA) in 1985. Professor Sen visited, Rutherford Appleton Laboratory in 1981 and 1995 under Indo-British Academic Link Programme to work in the field of Microwave and Millimeterwave Radiometry, Earth/space links, and Dual polarisation Doppler Radar. He also visited in 1991, University of Rano, USA, Georgia Institute of Technology, Atlanta, USA and Radar & Remote Sensing Laboratory, University of Cansas, USA and delivered lectures in these organisations, on "Millimeterwave Technology and Wave Propagation studies at Calcutta University", and also interacted with the experts of Hughes Aircraft Company, LOS Angeles, U.S.A. on Millimeterwave Technology. In 1997, he was invited by 1997 IEEE MTT-S International Symposium at Denver, Colorado, where he focussed the pioneering works of Sir. J.C. Bose, in Calcultta, India on Radio Science by an invited talk and by demonstrating the Historical Exhibits of Sir J.C. Bose. He is a Fellow of the institute of Electronics and Telecommunication Engineers FIETE (L), life member of Society of EMC Engineers (India), Astronomical Society of India (ASI), Indian Astronomical Society (ASI), Indian Science News Association (ISNA) and West

Bengal Academy of Science and Technology (WBAST), member of Indian National Committee for Solar Terrestrial Physics (STP) (1982-85), PAC on Atmospheric Science, DST (1991-94), National Management Committee for Research and Training Programme of GMRT (1991-94), Indian National Committee of URSI (1985-89), its Member Secretary (1988-91), CCIR National working group 5 (1992-94) and National Radar Council (NRC) working Group in Radar and Navigational Aids, (1989-93). Professor Sen also undertook Collaborative R & D work under IMAP/IMAP (C), with Space Application Centre, ISRO on Radiometric Remote sensing of atmospheric environment, worked with Department of Civil Aviation (NAA) on Radar data communication by Microwave link and with Bose Institute and Saha Institute of Nuclear Physics, Kolkata, on High Altitude Hill Station observation of Solar microwave bursts and particle emissions.

Dr. A.B. Bhattacharya obtained M.Sc. in 1973 and Ph. D. in 1980 from Calcutta University. He is currently working as a Reader in the Department of Physics, University of Kalyani, Kalyani-741235. He worked with Professor E.R. Williams at the Massachusetts Institute of Technology. USA, as a postdoctoral fellow in the Earth. Atmospheric and Planetary Sciences Division after selection by the Ministry of Education, Government of India, as a National Scholar.

Dr. Bhattacharya has been engaged in the studies of ionospheric propagation, Solar flare effects and various geophysical effects for about two and a half decades. His contributions in those fields have been well recognised. He has to his credit about ninety five research papers published in reputed journals. He worked in close collaboration with leading laboratories like Massachusetts Institute of Technology (MIT), Cambridge , Lincoln Laboratory and also at the Millstone Hill Observatory, USA. He has presented contributory as well as invited review papers at different International Symposia in many Countries.

Presently Dr. Bhattacharya is the Investigator-in-Charge of an ECRA (Eastern Centre for Research in Astrophysics) Project entitled "Development of a low cost solar radio telescope in the L-band and also engaged in a few collaborative research work such as on Microwave communication, with the National Physical Laboratory, New Delhi. On Integrated image processing system, with ISI and Department of Atmospheric Science (C.U.) and on Log Periodic dipole arrays and Solar burst studies with the Centre

of Advanced studies in Radio Physics & Electronics, Calcutta University. He has a number of Ph. D. students in the field of Wave Propagation, Atmospherics, Bionics and Solar-terrestrial relationships.

Dr. Bhattacharya is the author of eight text book like Radar System and Radio Aids to Navigation (Khanna Publishers), Advanced Practical Physics (Medical Allied Agency), Transistors and Integrated circuits (Central Publishing Concern) etc. and member of various scientific organisations.

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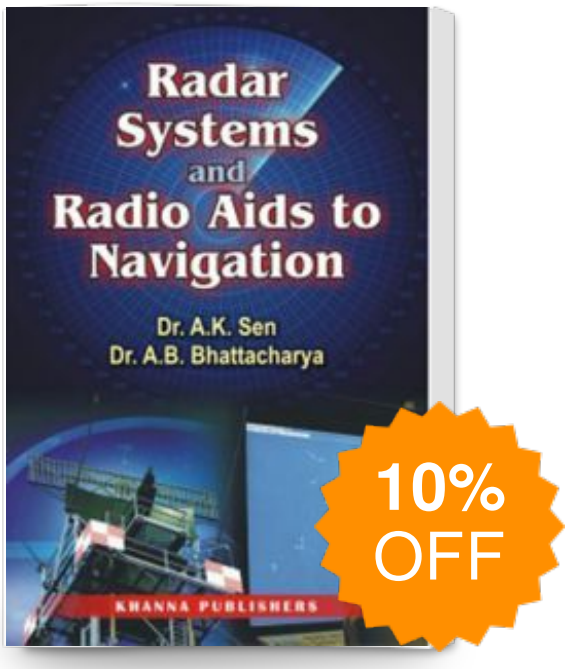

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